Monthly Report #1

Hydrogen-Oxygen APS Engines

NAS 3-14354

Period Ending July 30, 1970

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August 6, 1970

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Prepared for

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Monthly Report #1

I. PROGRAM OBJECTIVES

The primary objective of this contract is to generate a comprehensive technology base for high performance gaseous hydrogen-gaseous oxygen rocket engines suitable for APS. The technical objectives will be accomplished and reported on in a twenty-one task program summarized below. The first ten tasks relate to high pressure APS engines; Tasks eleven through twenty relate to low pressure APS engines and Task twenty-one is a common reporting task.

Exhibit "A" Task	Task Titles for High Pressure APS Engines
I	Injector analysis and design.
II	Injector fabrication.
III	Thrust chamber analysis and design.
IV	Thrust chamber fabrication.
V	Ignition system analysis and design.
VI	Ignition system fab and checkout.
VII	Propellant valves preparation.
VIII	Injector tests.
IX	Thrust chamber cooling tests.
X	Pulsing tests.

Exhibit "A" Task	Task Titles for Low Pressure APS Engines
XI	Injector analysis and design.
XII	Injector fabrication.
XIII	Thrust chamber analysis and design.
XIV	Thrust chamber fabrication.
XV	Ignition system analysis and design.
XVI	Ignition system fabrication and checkout.
XVII	Propellant valves preparation.
XVIII	Injector tests.
XIX	Thrust chamber cooling tests.
XX	Pulsing tests.
	Common Task
XXI	Reporting requirements.

I. Program Objectives (cont.)

The first report covers the high pressure engine technology portion of the contract only, since the start date of the low pressure phase is scheduled for the second program month.

The technical activities discussed in the next section correspond to Tasks I - X and are discussed in order.

II. PROGRAM PROGRESS

A. TASK I - INJECTOR ANALYSIS AND DESIGN

Design of a coaxial element injector was initiated in mid-July. The analysis and design focuses on two relatively independant areas. One is the configuration of the injector body which contains the propellant manifolds, thrust take-out brackets and flanges for thrust chamber and propellant feed attachments, and, of course, provisions for propellant injection elements. Optimization of the element configuration which will be incorporated in the injector body is the second area which is being investigated. The final element configuration will evolve from a series of planned cold flow tests.

1. Injector Body Design

The injector body is being designed such that either a bolted or welded assembly procedure can be employed. The initial body has the oxidizer and fuel manifold cover bolted in position and therefore allows access to critical flow control and distribution areas. This first unit also serves as a cold flow model for the propellant manifolds. The need for flow distributing devices will be established in the flow tests. Design activity in this area is about 70% complete and materials sufficient to fabricate up to 4 injector bodies have been ordered. The material selected for the injector body is 304L because of its excellent joining properties to itself by Electron beam welding or brazing and to nickel elements by brazing.

II,A, Task I - Injector Analysis and Design (cont.)

2. Injector Face Design

The above body is being designed to incorporate a variety of cooled face plates as follows:

Face Cooling Concept	Material Form	Material Type
Transpirtation cooling	Etched plates, rigimesh	Stainless steel or Ni
Film cooling	Thin plate	Ni or Cu
Conduction convection cooling	Thick plate	Cu or Cu alloys

The relative merit of being able to mechanically remove these face plates is being evaluated and a thermal analysis has been initiated to determine the face temperatures for each of the cooling approaches. The ability of these faces and cooling methods to provide 10^6 thermal cycles will be a determining factor in the final selection.

3. Injector Elements

Forty-two coaxial elements have been tentatively selected for use in the injector body. This selection has been made by taking into consideration physical spacing limitations, oxidizer injection velocity and hydrogen cross flow velocity between the oxidizer element posts. A summary of the element configuration to be investigated in element cold flow studies is presented below:

No elements		42
Approx. Spacing	in.	.45
Ox tube dia at injection	in.	.264
Fuel gap	in.	.017
Oxidizer injector Vel.	fps	100
Fuel injector vel.	fps	1200

II, A, 3, Injector Elements (cont.)

The element cold flow tests have been configured to investigate the effect oxidizer post recess and the use of swirlers and other flow control devices on the oxidizer inlets.

Designs for an impinging coaxial element injector have also been completed. This concept also offers the ability to modify the element configuration by changing the face plates. The final face plate element pattern to be employed on injectors to be fabricated on this contract will be selected on the basis of element cold flow data which is now being evaluated.

B. TASK II - INJECTOR FABRICATION

No activity schedule for injector fabrication. Cold flow model fabrication was delayed one week.

C. TASK III

No activity scheduled.

D. TASK IV

No activity scheduled.

E. TASK V - IGNITION SYSTEM ANALYSIS AND DESIGNS

The thermal analysis of the spark igniter was updated to incorporate the experimental heat flux obtained from initial heat sink igniter tests. The initial test series consisted of short duration (0.1 sec) tests in a .05 in. thick Hastelloy X chamber which had 7 backside thermocouples located along the axis and around the periphery. The experimental data indicated that the heat flux calculated from the theoretical combustion temperature at nominal mixture ratio and the simplified Bartz correlation for local heat transfer coefficient was

II, E Task V - Ignition System Analysis and Designs (cont.)

adequate for design. The result of the updated analysis using the experimental data indicated the current igniter configuration to be thermally marginal. Methods of reducing the igniter operating temperature such as increasing the coolant velocities, changing to a nickel wall and adjusting the mixture ratio are being evaluated.

The design of a catalytic igniter is also being modified to incorporate the most recent thermal data and analysis.

F. TASK VI - IGNITER CHECKOUT TESTS

Five electrical igniter only checkout tests were conducted. Four were conducted in instrumented uncooled igniter chambers to get thermal data at igniter core mixture ratios (O/F) of 35 and 50. The fifth test was conducted in an unmodified cooled configuration (low coolant velocity) at mixture ratio of 35 and resulted in over-heating of the Hastelloy X chamber.

G. TASKS VII - PROPELLANT VALVE PREPARATION

Drawings of the low pressure drop valves assembly are being completed. The design incorporates a standard valve barrel assembly fabricated by Controls Components Inc. and an Aerojet design valve body and pneumatic actuator.

H. TASKS VIII - X

No activity scheduled.

I. TASK XXI

Work plans for the high and low pressure engine portions of this contract were prepared and submitted for approval on schedule.

III. CURRENT PROBLEMS

No significant technical or scheduling problems are foreseen at this time.

IV. WORK TO BE PERFORMED IN NEXT REPORT PERIOD (BY TASK)

TASK I - 1. Cold flow single coaxial element and optimize configuration.
2. Complete design of coaxial element injector.
3. Select face pattern for impinging coaxial injector.
4. Evaluate manifold cold flow data for impinging coaxial element injector.

TASK II -1. Initiate fabrication of cold flow single elements and element tester.
2. Initiate fabrication of coaxial element injector body.

TASKS III & IV - No activity.

TASKS V & VI - Modification of the igniter coolant circuit, thermal characteristics and igniter checkout tests.

TASK VII - Completion of the valve design and initiation of fabrication.

TASK XIII - Coaxial element cold flow.

TASK IX & X - No activity.

Enclosure I
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION Lewis Research Center	CONTRACT PROGRESS SCHEDULE	REPORT FOR MONTH ENDING 30 July 1970	FORM APPROVED BUDGET BUREAU NO. 104-R0007	9. NASA Use Only a. NASA CODE
1. CONTRACT TITLE Hydrogen-Oxygen APS Engines	2. CONTRACTOR (Name and address) Aerojet Liquid Rocket Co., P.O. Box 15847 Sacramento, California 95813		3. CONTRACT NO. NAS 3-14354	b. PROJECT MGR.
	4. APPROVED (Contractor's Project Manager) L Schoenman	PREPARATION DATE 8/6/70	5. NASA APPROVED SCHEDULE DATE	c. EVALUATION DATE

	6. REPORTING CATEGORY	7. 1970 J	A	S	O	N	D	1971 J	F	M	A	M	J	J	8. TECH. OBJECTIVE % COMP.	d. EXCEPTION CATEGORY e.	f.	g.
a	Injector Analysis and Design														30			
b	Injector Fabrication																	
c	Thrust Chamber Analysis and Design																	
d	Thrust Chamber Fabrication																	
e	Ignition System Analysis and Design																	
f	Ignition System Fabrication and Checkout																	
g	Bipropellant Valve Preparation																	
h	Injector Tests																	
i	Thrust Chamber Cooling Tests																	
j	Pulsing Tests																	

NASA C-62 Rev 1-68

NASA APPROVED SCHEDULE

CONTRACTOR'S WORKING SCHEDULE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Lewis Research Center

CONTRACT PROGRESS SCHEDULE

REPORT FOR MONTH ENDING: 30 July 1970

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3. CONTRACT NO.: NAS 3-14354

4. APPROVED (Contractor's Project Manager): L Schoenman

PREPARATION DATE: 8/6/70

5. NASA APPROVED SCHEDULE DATE

6. REPORTING CATEGORY	7. 1970 J	A	S	O	N	D	1971 J	F	M	A	M	J	J	8. TECH. OBJECTIVE % COMP.	e.	f.	g.
Program Plan and Test Plans														25			
Monthly Reports														11			
Quarterly Reports																	
Final Report Draft																	

NASA C-? (Rev. 1-68)

NASA APPROVED SCHEDULE
CONTRACTOR'S WORKING SCHEDULE